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ABSTRACT

This study determined the role of self-efficacy on women's selection of math-related careers. Unlike a similar study conducted by Zeldin and Pajares (2000), this study included African-American women. It centered on Banduras (1986, 1987) four sources for self-efficacy perceptions (mastery experiences, vicarious experiences, verbal persuasions, and physical and emotional states) by reviewing the personal narratives of women who selected and continued to excel in careers in the area of mathematics. The research question was which of the four sources contributed the most to self-efficacy. Participants were five women (three Caucasian and two African-American) in math-related careers. Zeldin and Pajares semi-structured, open-ended interview protocol was used. Analysis of participants responses indicated vicarious experiences and verbal persuasions were instrumental sources for the development and maintenance of self-efficacy beliefs for women in math-related careers, and these women demonstrated a great amount of persistence and effort while they continued along their academic and career paths. Participants did not rely totally on skill to succeed in pursuing math-related careers; instead, they relied on people with whom they had positive relationships. (Contains 22 references.) (YLB)

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## WHY MATH CAREERS? WOMEN'S SELF-EFFICACY BELIEFS

A review of college enrollment indicates that the number of women attending college has increased so that they are currently the majority; however, when one looks at the majors that women are choosing, a disparity appears in math-related careers (Sadker & Sadker, 1994). The under representation of women in math-related careers is believed by social cognitive researchers to be the self-beliefs women hold about their capabilities (Bandura, 1997, Hackett & Betz, 1981; Zeldin & Pajares, 2000).

Social cognitive researchers hold as a basic tenet, self-belief. In the Bandura's social cognitive theory, the person is the agent of change. The theory emphasizes the relationship between personal and environmental factors, which are dependent upon each other (Corsini & Wedding, 1989). Therefore, the central construct of Bandura's social cognitive theory is self-efficacy, which is defined as people's judgments of their capabilities to produce designated levels of performance (Zeldin & Pajares, 2000). These judgments according to Bandura will affect a person's choices, effort, persistence, and resiliency (Bandura, 1986, 1997).

According to Bandura (1986, 1997), people form their self-efficacy perceptions by interpreting information from four sources: mastery experiences, vicarious experiences, verbal persuasions, and physical and emotional states. Research has proven that the most important of the four is mastery experiences or performance accomplishments (Bandura, 1986, 1997; Lent, Lopez, & Bieschke, 1991; Gavin, 1996). **Mastery experience** is how one interprets past success or failure in accomplishing a task. Continued success generates high self-efficacy while continued failure can lower self-efficacy beliefs. In a study by Hackett (1995), women were shown not likely to continue in traditionally male domains such as mathematics when their judgments of personal competence are low.

Human personality is strongly determined by the ability to acquire new responses by watching someone else performing a task and then doing it ourselves. One tends to learn what to do and what not to do by observing positive and negative consequences experienced by others. Bandura called this aspect of the development of self-efficacy, **vicarious experiences**. Evidence of the effect of vicarious experiences can be seen in the fact that women and men have different sex-typed experiences in childhood which limit women's exposure to the sources of information necessary to develop strong self-efficacy perceptions in traditional male dominated careers such as mathematics (Eisenberg, Martin, & Fabes, 1996).

**Verbal persuasions** are positive verbal messages and social encouragement that enables one to exert the extra effort and maintain the persistence required to succeed, which results in a higher level of self-efficacy. In a study by Becker (1984), women report being in need of more persuasion from at least one person, usually a teacher, to pursue a graduate degree in mathematics.

**Physical and affective statuses** include the amount of stress or tension and mood. Stress and tension have a pronounced effect on someone's ability to succeed, and so does mood. Thinking positive can enhance one's self-efficacy while despair and depression lowers self-efficacy. In a study by Gavin (1996), attitudes were integral in decisions to study mathematics. According to Swanson and Woitke (1997), whether experiences reinforce or promote low levels of self-efficacy depends upon the individual's perceptions and whether or not the barriers are overcome. The way African American girls and women perceive barriers influences in part their ability to predict how the environment will respond to their behavior or performance in a given situation (Stitt-Gohdes, 1997).

This study is very similar to one conducted by Zeldin and Pajares (2000); however, Zeldin and Pajares did not focus on careers in math-related fields nor did their study include any African Americans. Therefore, the purpose of this study was to determine the role of self-efficacy on women's selection of math-related careers and to include in the study African American women. The study centered on Bandura's four sources for self-efficacy perceptions by reviewing the personal narratives of women who selected and continue to excel in careers in the area of mathematics. The research question was which of the four sources contributes the most to self-efficacy.

## Methods and Procedures

Traditionally, self-efficacy research has been overwhelming quantitative; however, Pajares (1996, 1997) and Schunk (1991) have argued that deeper insights must come from qualitative research that provides rich description through narrative. To assist researchers in understanding qualitative research, Bogdan and Biklen (1992) identified several characteristics of a qualitative study. Data collected for qualitative research is descriptive because it consists of words rather than numbers. The written word is important to the qualitative researcher not only in recording data but also in disseminating the findings. In qualitative research nothing is taken for granted, everything has the potential of being a clue that might unlock the mystery of what is being studied. Qualitative researchers are concerned with process rather than the outcome and do not search out data to prove or disprove hypotheses. The essential component of qualitative research is meaning. Meaning is learning the perspectives of the participants that illuminates the inner dynamics of situations that are often invisible to the outsider. After reviewing these criteria, it was determined that a qualitative study would be the most appropriate research design for this study. The particular qualitative investigative method chosen was interviewing, which was the dominant strategy for data collection.

### Participants

Participants were 5 women, 3 Caucasian and 2 African Americans, who currently have a math-related career that relies extensively on the use of mathematics or has had mathematics as a prerequisite (See Table 1). Several careers fulfilled the criteria for this study: mathematics professors, teachers, researchers, chemists, physicists, computer software developers, accountants, and engineers. Because the proportion of women in these careers is small, a sample was very difficult to find. Participants were selected by a

combination of network selection and primary contacts. Area universities and colleges, organizations that promote women, and the local chamber of commerce were contacted for names of women who fulfilled the criteria. Women who agreed to participate in the study were asked to recommend other women who might be interested in participating.

Table 1
**Background of Participants**

| Name | Age | Ethnicity | Educational Background | Occupation |
|---|---|---|---|---|
| Lillie | 47 | African American | B.S. Education | Math Teacher |
| Monica | 33 | African American | B.S. Accounting | Accountant |
| Tara | 22 | Caucasian | B.S. Accounting | Accountant |
| Susan | 55 | Caucasian | B.A. Mathematics MBA | Director of Business and Economic Research |
| Barbara | 34 | Caucasian | B.S. Civil Engineering | Civil Engineer |

Instrumentation

After surveys used in previous research were reviewed, it was determined that the Zeldin and Pajares' protocol questions (2000) were designed to correlated with an understanding of the sources of self-efficacy that was consistent with previous theoretical tenets. The open-ended interview protocol designed by Zeldin and Pajares was employed. The interview was semi structured, allowing for both standardization needed to acquire similar information from each participant as well as flexibility required during individual administration. The same questions were asked of each participant in a similar order to remain focused on the participants' self-efficacy beliefs.

The protocol began with a question about the participant's background. It included information about family background, academic background, and career history. The second question asked the participant to describe her current occupation. This information gave the researcher a better understanding of the participant's career. The next five questions focused on the four sources of self-efficacy. Questions 3 dealt with experiences that the participant believed lead her to pursue a math-related career. A description of mastery experiences was the goal of this question. Question 4's focus was how the participant had observed and learned from others and whether these vicarious

experiences had an influence on the participant's self-efficacy. Verbal persuasion was the focus of Question 5. Question 6 was intended to elicit information concerning the participant's feelings and beliefs about mathematical as she was pursuing her math-related career.

The remaining three questions dealt with trying to better understand why the participant chose a math-related career and what could be done to encourage more women to pursue math-related careers. The first question was a request for the participant to tell a memorable story of why she chose a math-related career. The second question asked why the participant believes that so few women choose math-related careers. The last question asked if the participant would do anything differently.

Data Collection

The researcher contacted each recommended participant by telephone and explained the purpose of the study to be an investigation of women in math-related careers. Participants were asked to participate in an in-person interview, but the participants declined because of lack of time. They did agree to complete the protocol if it was sent to them. The protocol was mailed to each of the participants. The participants were ensured that their names, the names of their companies, and the names of the people that they might discuss would be kept confidential.

Data Analysis

Using coding categories, a means of sorting the descriptive data that was collected so that the material bearing on a given topic can be physically separated for other data, each response was reviewed for commonalities and patterns of relationships (Bogdan & Biklen, 1992). Pattern coding is a way of grouping summaries of initial data into a smaller number of sets, themes, or constructs. Recurring phrases and common threads in the participants' academic and career histories were sought.

Reliability and Validity

In qualitative studies, researchers are concerned with the accuracy and comprehensiveness of their data. Qualitative researchers tend to view reliability as a fit between what they record as data and what actually occurs in the setting under study, rather than the literal consistency across different observations.

## Results and Discussion

Just as in Zeldin and Pajares'(2000) study, two themes emerged from the analysis of the participants' responses. The first was that vicarious experiences and verbal persuasions were instrumental sources for the development and maintenance of self-efficacy beliefs for women in math-related careers. The second theme was that these women demonstrated a great amount of persistence and effort while they continued along their academic and career paths.

Theme One: Vicarious Experiences and Verbal Persuasions

Most of the women responded that someone in their family had been an influence in strengthening their self-efficacy in mathematics. Three of the five, two Caucasians and

one African American, identified specific family members who had encouraged them to pursue math-related careers. The form of encouragement took both verbal persuasions and vicarious experiences. Susan, a director of business and economic research, told about her mother being gifted in mathematics and how she had always shown true interest in mathematics. Barbara, a civil engineer, spoke of her father encouraging not only her but also her sister to pursue a math or science based career. Her sister is a mechanical engineer. Monica's sister attended Howard University and graduated in accounting. Monica said that the reason she became an accountant is because she wanted to be just like her sister. Because family members had an interest and competence in the area of mathematics, it was only natural, according to Bandura, for the participants to have the same-shared qualities.

The two other women identified a mentor and a teacher as being responsible for them pursuing math-related careers. Tara said that she became an accountant because during college she had a part-time job in an accounting department. She told about working with an accountant who provided words of encouragement. Her family was not supportive. The accountant was a motivator for Tara through his persuasive words and encouragement. Lillie, a classroom math teacher, shared a story about an eighth grade math teacher who encouraged her in the area of mathematics. She talked about how she wanted to become just like him. He was highly influential in the development of her competence and confidence because he cared.

Theme Two: Resiliency

A pattern of resiliency along the participants' academic and career was demonstrated by all. These women persevered no matter what obstacles where set in front of them. Tara's was not strong in math, but desperately wanted to be an accountant. She talked about how she made herself think that accounting was not math. She believes this is what caused her to be able to overcome her perception that she was not good in math. The guys in Monica's math classes gave her a hard time. They constantly were telling her that math-related careers were not a woman's profession. She clung to her family's words of encouragement to get her through the tough times. Susan, like Tara, talked about the difficulty of the math classes. She said that as she progressed through the curriculum the courses became harder and harder. She got through them because she found great satisfaction in solving problems, gaining understanding of situations, and coming to the end of a project. She talked about how math appeals to the senses while most other areas of study appeal to the emotions as well as the senses. For her, the thrill of problem solving brought an emotional release. She focused on the "high" of figuring things out. Barbara's peers thought of her as a geek. She felt that some of her family members, teachers, and friends tended to stereotype women in career other than mathematics. She focused on her positive math experiences to help her overcome the negative remarks. Lillie shared her experiences as a math teacher for the past 26 years and how she is still pursuing higher-level degrees. She stated that her love for mathematics has sustained her through the years. Even though Monica has a nonsupportive husband and 3 small children, she still pursued her career in accounting. Her present job allows her to work out of her home. She attributed her determination to her father's emotional support.

After reviewing the data, it was evident that the participants' perseverance and resiliency had been primarily strengthened by the vicarious experiences and verbal persuasions with people who had played a significant role in their lives. This conclusion supports the tenets of Gilligan (1982) and Noddings (1992) that suggest that women's beliefs are based upon an ethic of care. According to Gilligan, women use the significant relationships in their lives as a foundation on which to ground their behavior.

## Conclusion and Implications

A review of the data showed that the participants did not rely totally on skill to succeed in pursuing math-related careers. Instead they relied upon people with whom they had positive relationships. These people influenced the self-efficacy beliefs of the participants by the confidence that they expressed in the participants' abilities and by caring.

If our goal is to increase the number of girls and women participating in math, we must do things differently in our classrooms. Karp and Shakeshaft (1997) offer the following solutions to overcome the disparity of women in math-related careers: establish role models for women, eliminate speediness, encourage cooperative learning, design meaningful instruction, identify female flight, and supervise instruction. Brophy (1998, p. 2) suggests strategies for helping students improve self-efficacy:

- Act more as resource persons than as judges.
- Focus more on learning processes than on outcomes.
- React to errors as natural and useful parts of the learning process rather than as evidence of failure.
- Stress effort over ability and personal standards over normative standards when giving feedback.
- Attempt to stimulate achievement efforts through primarily intrinsic rather than extrinsic motivational strategies.

However, when one reviews the lists of strategies, you find the common goal for both Karp and Shakeshaft and Brophy is to build relationships. If building relationships is the primary focus, then mentoring becomes a powerful tool. Mentoring is an informal, positive relationship in which experienced persons develop a supportive relationship with someone who is a novice. Didion (1997) believes that mentoring is essential for success. Positive interactions with mentors from the community, family, or school help girls and women achieve their educational goals. One way to accomplish this task is through telecommunications which has opened up a new avenue for building relationships. Time is a variable; however, recognizing that women represent a small percentage of those who pursue math-related careers provides an impetus for giving generously of our time to build those significant relationships.

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